

Wheat Stem Sawfly in Colorado – Frequently Asked Questions

Punya Nachappa and Erika Peirce

Q: What type of insect is wheat stem sawfly?

A: Wheat stem sawfly is not a fly but a wasp! They belong to a group of insects called Hymenoptera alongside ants, bees, and wasps. These wasps cannot sting. The name “sawflies” comes from the saw-like appearance of the ovipositor, which the females use to cut into the plants where they lay their eggs. Males lack this trait.

Q: How do I know if I have wheat stem sawfly in my field and what do they look like?

A: Starting in early to mid-May, look for small yellow and black wasps (7-12mm) on wheat plants along the edges of the field. Resting sawflies will sit on the stem facing the ground. There are insects that are similar in appearance, but they would not have this resting posture or be abundant in field edges. In mid to late-June, stems can be cut open to look for the white, S-shaped larvae or the sawdust-like material resulting from their feeding.



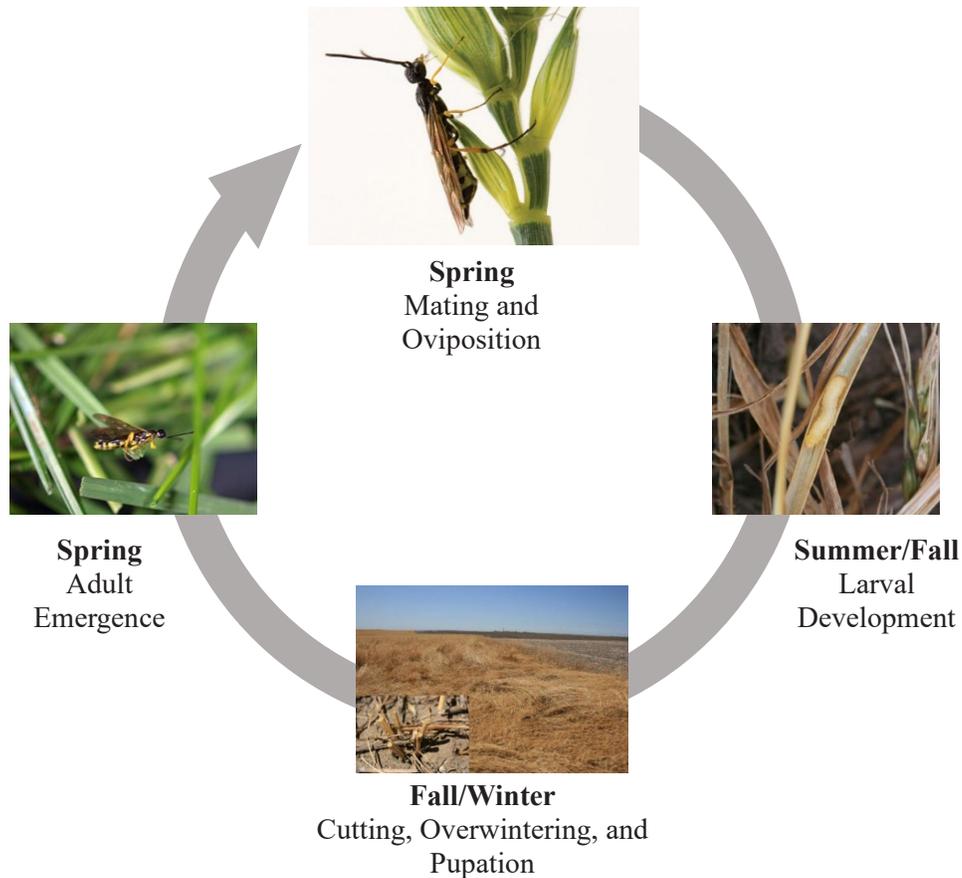
Adult female wheat stem sawfly sitting facing the ground (left). Wheat stem sawfly larva in stub (right).

Q: What does wheat stem sawfly damage look like?

A: Before the stems dry, you can cut open stems to look for larvae, as well as the sawdust-like material resulting from their feeding. When the larvae finish feeding, they cut the insides of the stems near the soil, making them prone to lodging, especially after strong winds. Unlike stems lodged from other causes, cut stems are no longer connected to the plant.

Q: What is the life cycle of wheat stem sawfly?

A: Wheat stem sawfly has a single generation per year. Adult wheat stem sawflies emerge from previous year's stubble from May to June and females lay their eggs inside wheat stems. Although several eggs may be laid within a stem, only a single larva survives to maturity. As the plant matures the larva moves down to the base of the stem and chews a notch around the inside of the stem. The notch usually causes the stem to break, producing a stub that remains anchored in the ground. This stub is then filled with frass, which creates a protective chamber where the larva overwinters and undergoes pupation. The new adult either chews through the frass plug or the side of the wheat stub to start the cycle again.



Life cycle of wheat stem sawfly. Photo credits: Bugwood.wiki, Kelsey Dawson

Q: How do weather patterns impact sawfly movement and would severe cold temperature kill off larvae?

A: Dry weather favors wheat stem sawflies and excessively wet conditions tend to be detrimental to both sawfly and parasitic wasp populations and activity. Severe cold as seen during the winter storm in 2020 will not affect the wheat stem sawfly populations as they are known to tolerate much colder temperatures in Canada.

Q: Do we find wheat stem sawfly in all wheat-producing counties?

A: Yes, as of 2020 wheat stem sawfly has been found in wheat in all wheat-producing counties in Eastern Colorado. Most damaging infestations have been found in North Central Colorado, with a few lighter infestations occurring as far south as Baca County. Economically significant infestations are spreading to the south and east.

Q: Where are the wheat stem sawflies coming from?

A: The wheat stem sawfly is native to Colorado and was first discovered in 1872 on non-cultivated grasses. Many believe that the insect adapted to wheat as European settlers began large-scale cultivation of cereal crops. It has long been a threat to spring wheat production in the northern plains and has become as a significant pest of winter wheat as well.

Q: Why are we starting to have wheat stem sawfly problems now?

A: There is no good answer to this question, but it likely is due to some combination of the changes in the wheat stem sawfly's preference for wheat, changes in production practices (e.g., reduced tillage), and changes in climate.

Q: What is the estimated crop loss due to wheat stem sawfly in Colorado?

A: The annual economic loss in Colorado is conservatively estimated at \$30M.

Q: How fast can wheat stem sawflies spread?

A: According to CSU survey results, damage in wheat was mostly limited to the New Raymer area in 2012. By 2020, wheat stem sawfly was found in all Eastern Colorado wheat-producing counties. As of 2020, heavily damaging populations can be found as far south as I-70, with most hotspots centering in the North Central part of the state.

Q: Can we predict wheat stem sawfly infestations ahead of time?

A: According to Canadian guidelines, greater than 10-15% cutting in wheat stems from the previous year indicates that adjacent fields should be planted to something other than wheat or to a resistant variety.

Q: What are the hosts of wheat stem sawfly?

A: The cultivated hosts of wheat stem sawfly are limited to cereal grains with similar life cycles to wheat (winter/spring wheat, triticale, barley, rye). Wheat stem sawfly is not known to lay eggs in oats or flax. The list of native and non-native grass hosts of the wheat stem sawfly is extensive and includes brome grasses, wheat grasses, wild ryes, and many other species commonly found in the state.

Q: What rotation crops can reduce the level of wheat stem sawfly infestation?

A: None of the common rotational crops (corn, proso millet, sorghum, sunflower) are affected by wheat stem sawfly. It is very important to plan rotations to avoid planting new wheat immediately adjacent to stubble infested during the previous crop. Crop rotation also has disease and pest management, and soil fertility benefits.

Q: How long do I have to stay out of wheat to reduce the problem so I can go back to wheat with minimal loss of yield?

A: Wheat stem sawfly infests a wheat crop in May and June and will remain in the stubble from that crop until adults emerge the following spring. At that time, adult sawflies will disperse from the field looking for new wheat to infest, so that field could be planted to wheat that fall without risk of infestation by the sawflies from the previous year. However, sawflies from adjacent fields or from even greater distances may infest this new crop, and sawfly can be present in nearby native grasses.

Q: How effective is tillage in controlling the wheat stem sawfly?

A: Both fall and spring tillage have been used to expose crowns containing overwintering larvae to moisture and temperature extremes, but these practices have not been effective. Also, tillage will negatively impact the natural enemies that also overwinter in the stubs.

Q: Are there varieties that are resistant to wheat stem sawfly?

A: Yes, there are sawfly-resistant varieties that have a trait called “solid stem”. Solid stem varieties of wheat have been shown to be effective in impeding larval development and movement, thus reducing larval survival. CSU has released a semi-solid variety, Fortify SF, a medium-maturity variety with wheat curl mite resistance and a similar yield potential to Byrd under normal field conditions. It is not highly resistant because it has only a semi-solid stem, however, it is substantially more resistant than other locally adapted varieties. Breeding for WSS resistance is a high priority for CSU.

Q: What is known about the consistency of expression of stem solidness, or degree of resistance conferred by the new semi-solid varieties?

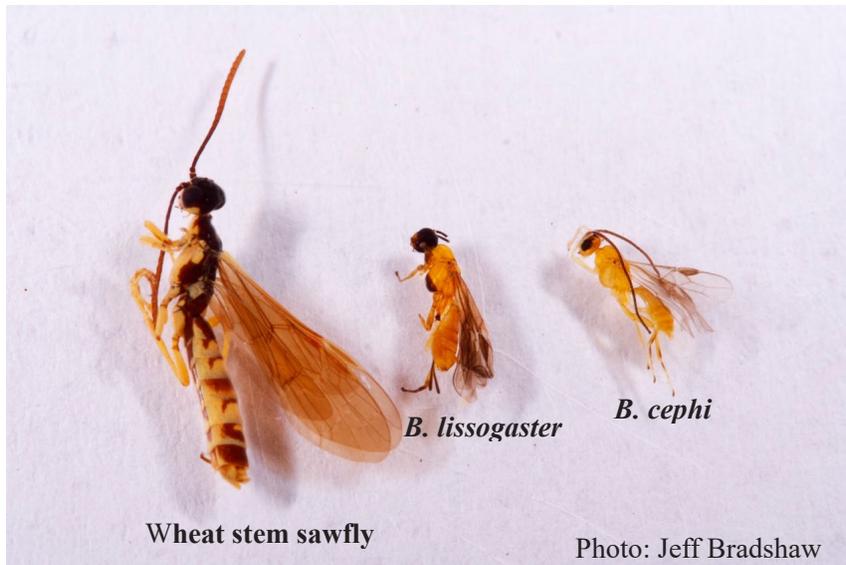
A: Reports from Montana and Canada suggest that certain environmental conditions, such as lower light intensity from increased cloudiness or lower elevation, may result in reduced expression of solidness. We do not yet know for certain how much of an issue this will be here in Colorado with our higher light intensities. The level of expression of semi-solidness observed has provided significant reduction in stem cutting in field trials.

Q: Is there a yield drag with the new semi-solid varieties?

A: There is a yield drag based on the Elite trials last year, comparing the unreleased semi-solid vs. solid stemmed lines. The yield drag was about 4.5% in the absence of wheat stem sawflies. Semi-solid varieties should outyield susceptible varieties if both are infested with sawflies.

Q: Does the wheat stem sawfly have any natural enemies?

A: A few insect species feed on wheat stem sawfly. The most important of these are two parasitic wasps, *Bracon cephi* and *Bracon lissogaster*, whose larvae can be found feeding on wheat stem sawfly larvae inside wheat stems.



Comparison of wheat stem sawfly and its parasitoids.

Q: How important are these parasitic wasps in Colorado?

A: To date, very few of either wasp species have been found feeding on wheat stem sawfly larvae infesting winter wheat. They are more easily found on wheat stem sawfly larvae infesting non-cultivated grasses. These wasps are considered to be important in the Northern Plains, which have a longer history of wheat stem sawfly infestations in wheat.

Q: Are there practices that will encourage the parasitic wasps that attack wheat stem sawfly?

A: These parasitic wasps are expected to become more important as they adapt to wheat stem sawfly infestations in wheat. Tillage and swathing are two practices known to affect them negatively. However, if provided with sugar resources, such as flowers, adult wasps can live longer and produce more offspring. Research has shown that incorporating buckwheat into cover crop mixes could enhance parasitoid performance.

Q: How can I control existing wheat stem sawfly infestations in my wheat?

A: Little can be done once your wheat is infested. No effective chemical controls are available. Stem cutting can be reduced by swathing. Stripper headers are better at picking up cut stems than traditional headers.

Q: Can wheat stem sawfly be controlled with insecticides?

A: The egg, larval, and pupal stages are found within the stem, making them inaccessible to insecticides. To date, no insecticides have been found to be effective at controlling wheat stem sawfly, however more research into the topic is being done.

Q: Will swathing my wheat reduce losses to wheat stem sawfly?

A: Wheat can be swathed before stem cutting starts. Disadvantages to swathing include the cost of an extra field operation and negative effects on the parasitic wasps that are feeding on sawfly larvae at this time. Costs can be reduced by swathing just the field margins, where infestations generally are more severe. Effects on natural enemies can be minimized by leaving the lower third of the stem intact.

Q: What is the best way to recover cut stems during harvest?

A: Combines equipped with stripper headers are most efficient in picking up cut stems at harvest.

Q: Can the wheat stem sawfly be eradicated?

A: No. To date, we have no appropriate management methods that can eliminate this insect from even a single field. Further, this insect is native to Colorado and well adapted to our environment. Finally, you would need to eradicate them from non-cultivated grasses as well as from wheat, which would be next to impossible!

Q: How do I prevent wheat stem sawfly infestations in my wheat?

A: Current preventive measures include planting semi-solid varieties, reducing the amount of wheat in your rotations to avoid planting new wheat next to previous crop stubble, and planting larger blocks to minimize the relatively severe infestations found in field edges.

Q: What research is being conducted at CSU in response to the wheat stem sawfly outbreak?

A: CSU is emphasizing the development of high quality, productive wheat varieties resistant to wheat stem sawfly. Other research projects include screening for novel sources of resistance in wild wheat species, improved biological control, trap crops, new approaches to chemical control and surveys to track the spread of this pest.

Acknowledgements:

Frank Peairs wrote the original document which was updated by Punya Nachappa with input from Darren Cockrell and Erika Peirce.

Thanks to Frank Peairs, Scott Haley, Esten Mason, Tyler Benninghoven, Brad Erker, Assefa Gebre-Amlak, Jerry Johnson, and Sally Jones-Diamond for providing questions and for reviewing earlier versions of this work.

Additional Resources:

https://wiki.bugwood.org/HPIPM:Wheat_Stem_Sawfly

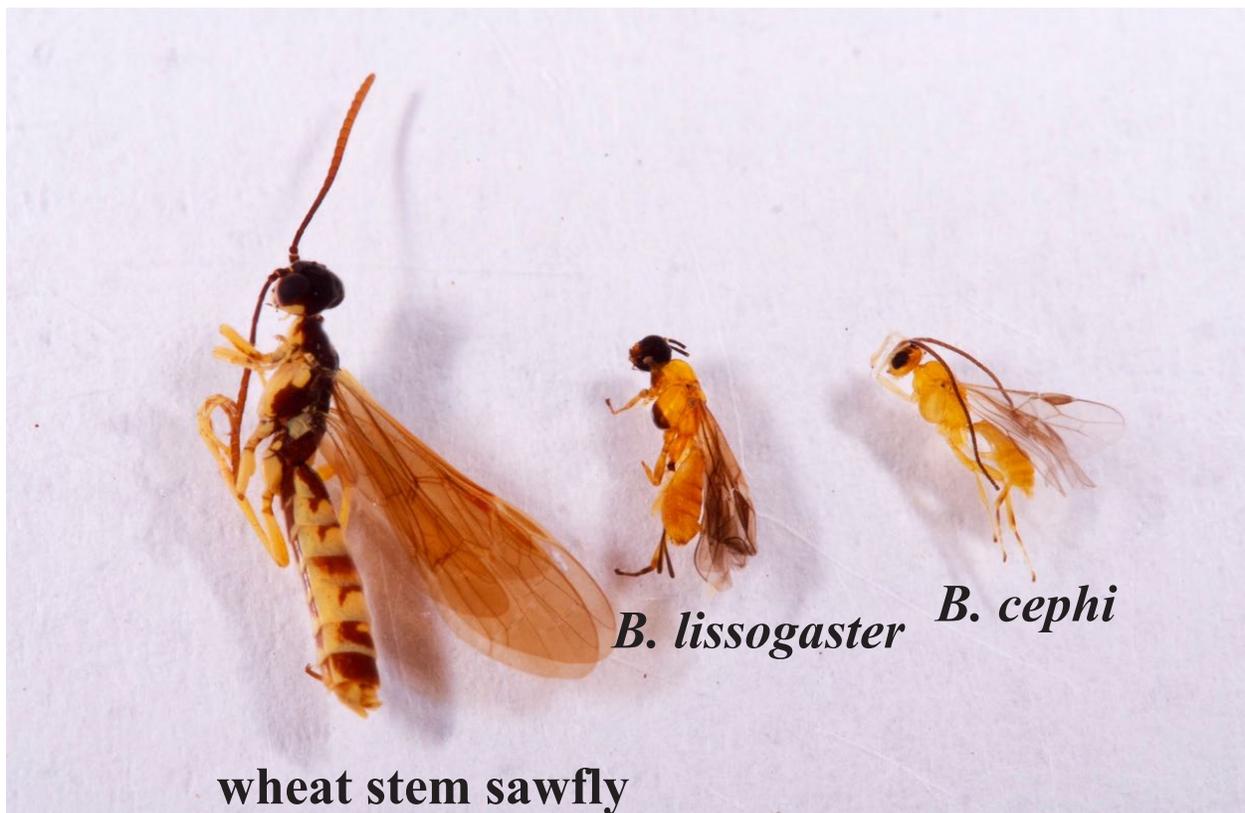
<https://extension.colostate.edu/topic-areas/insects/wheat-stem-sawfly-a-new-pest-of-colorado-wheat-5-612/>

<https://www.ag.ndsu.edu/publications/landing-pages/crops/wheat-stem-sawfly-e-1479>

Biological Control of the Wheat Stem Sawfly

Erika Peirce and Punya Nachappa

Background: *Bracon cephi* and *B. lissogaster* are the only known parasitoids to parasitize wheat stem sawfly (WSS) in spring and winter wheat in Canada ^{1,2}, Montana ^{3,4}, and Nebraska. Often *B. cephi* is the primary parasitoid encountered ⁴. The adults are about half the size of a WSS adult and are typically bright orange. The parasitoids will lay their eggs on WSS larvae in the stem and have two generations per year. Upon egg-laying, the WSS larvae are paralyzed, allowing the parasitoid larvae to feed. Under high WSS infestation, there are multiple larvae in the stem and they will cannibalize each other and consume any parasitized WSS larvae.



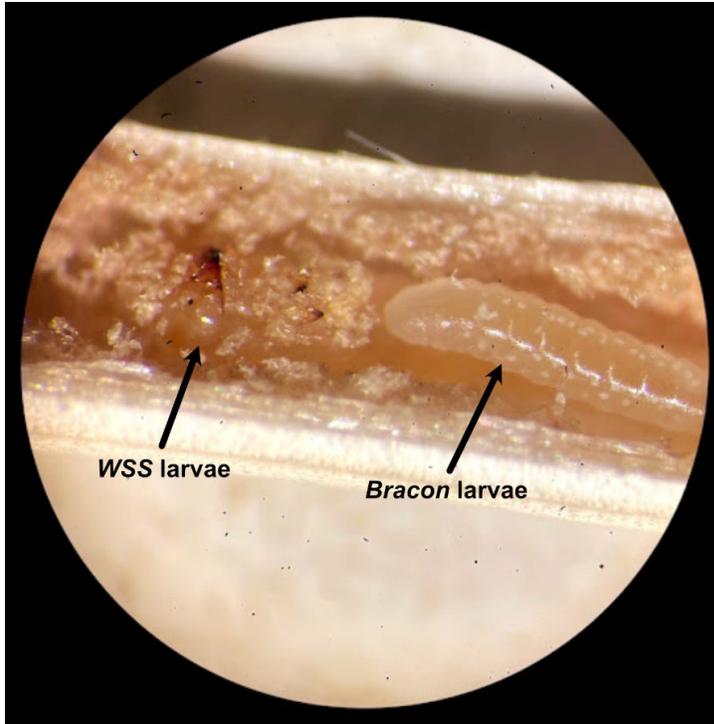


Figure 2: Parasitized WSS larva, with the remnants of the WSS larva and a developing parasitoid larva.
Photo credit: Erika Peirce



Figure 3: Parasitoid cocoon with developing pupa inside.
Photo credit: Erika Peirce

Parasitoid status in Colorado

We started by asking, are the parasitoids even in Colorado, and if so, can we find them in wheat? While doing our yearly surveys for WSS infestation, we also examine larvae for any presence of parasitism.

- We dissected 50,000 wheat stems and have not found a single parasitized WSS larvae.

From 2017 to 2019, we sampled seven different sites in Northern Colorado⁵. We were able to find small amounts of parasitism in the non-cultivated grasses i.e., intermediate wheatgrass, smooth brome, and western wheatgrass that were located directly next to wheat fields.

Further investigation is required to determine why we are not seeing parasitism in wheat, but we have two major hypotheses;

1. There could be very low levels of parasitism in fields, but we have not found any since it is like searching for a needle in a haystack,
2. The parasitoids are not emerging early enough to parasitize WSS in wheat.

Management strategies to improve parasitism

Several management strategies can increase parasitoid populations if they are present in wheat, even at low populations. Some strategies include:

- Reduced tillage, many parasitoid cocoons are located higher in the stems⁶,
- Solid stemmed cultivars reduce sawfly populations, allowing more parasitoids to survive⁷,
- Providing floral resources such as buckwheat can increase adult parasitoids' life span, allowing them to lay more eggs on WSS larvae⁸.

There is a chance we will begin seeing parasitism in Colorado wheat over the next few years. Therefore, we will be on the lookout and continue investigating ways to improve parasitism, such as field releases and how solid stem cultivars may impact parasitism survival.

Acknowledgements:

We would like to acknowledge the work of Dr. Frank Peairs, Darren Cockrell, and Dr. Tatyana Rand for their methods development and authorship of the complete results, the numerous lab technicians that collected and processed these samples, the countless wheat growers of Colorado that these samples were collected from, and the Colorado Wheat Administrative Committee for their support in this project.

Works cited:

(1) Nelson, W. A. et al. *Can. Entomol.* 85, 103–107 (1953). (2) Cárcamo, H. A., et al. *Biocontrol Sci. Technol.* 22, 367–369 (2012). (3) Runyon, J. B., et al. *J. Econ. Entomol.* 95, 1130–4 (2002). (4) Morrill, W. L., et al. *Biol. Control* 12, 159–163 (1998). (5) Peirce, E. S., et al. *J. Econ. Entomol.* 114, 72–81 (2021). (6) Runyon, J. B., et al. *J. Econ. Entomol.* 95, 1130–1134 (2002). (7) Weaver, D. K., et al. *J. Agric. Urban Entomol.* 21, 271–287 (2004). (8) Rand, T. A. et al. *J. Econ. Entomol.* 113, 2022–2025 (2020).

Colorado Wheat Stem Sawfly Survey

Erika Peirce and Punya Nachappa

Wheat stem sawfly (WSS) has been a pest of growing concern in Eastern Colorado since it was found in wheat fields in 2010 near New Raymer, Colorado. Adult sawflies emerge from wheat stubble in spring while the wheat crop is jointing and lay eggs over their flight period, which lasts 4-6 weeks. The eggs subsequently hatch and develop into larvae that chew the interior pith of the growing wheat stems. As the crop dries, the larvae create a hibernaculum near the root crown and cut the stems, causing lodging before the crop is harvested. Grain yield losses from wheat stem sawfly damage in Colorado were estimated to be \$30 million in 2020 (Dr. Frank Peairs and Dr. Scott Haley, personal communications).

From 2013 to 2020, the total number of sites infested across the state has increased steadily (Table 1). The number of sites with medium (11%-50%) and high (>50%) infestation levels also grew throughout the years, with 5 highly infested sites found in 2013 and 11 highly infested sites found in 2020. In 2016, 18 of the 81 sites that did not have WSS in stems had adult WSS in flight in the field, indicating that the sample timing was likely too early to fully capture that year's data.

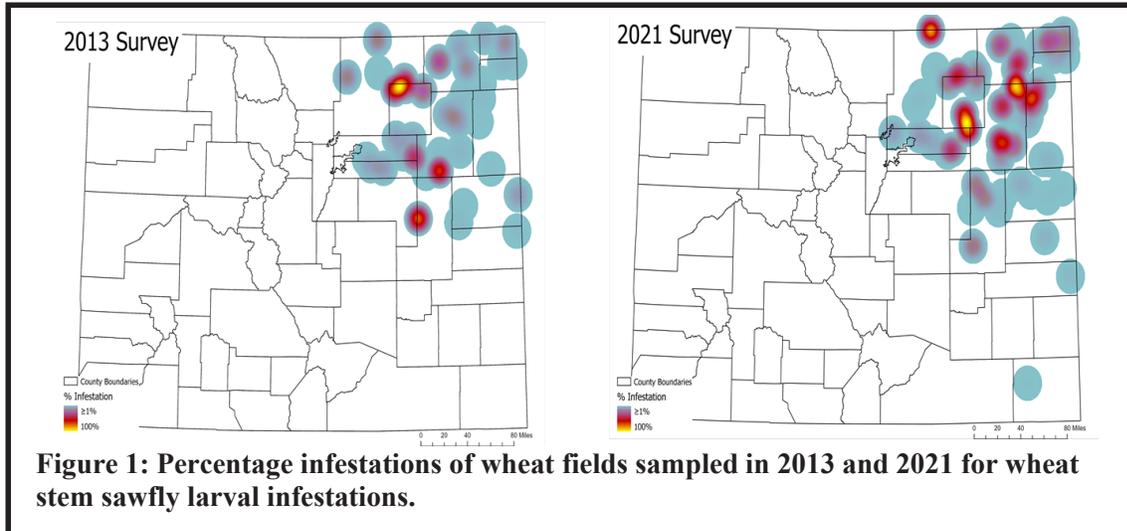
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Not Infested	56	50	32	81	42	46	41	33	44
<10%	20	30	48	11	36	26	29	41	33
11-50%	13	15	16	4	13	12	22	20	20
>50%	5	5	3	3	5	12	14	11	3
Total Sites	94	100	99	99	96	96	106	106	100

Table 1: Number of Colorado wheat fields found in each infestation percentage category using WSS larval infestations from 2013-2020.

From 2013 to 2021 the spread of WSS across the state has increased. In 2013 WSS was not found in Kiowa, Prowers, or Baca counties, while in 2020 WSS was found in all counties sampled (Figure 1). Notably, the areas in which highly infested sites were found in 2020 spread, with highly infested sites located as far south as the Adams/Arapahoe county border. In 2021 fewer sites sampled had WSS infestation. Low infestation may have been due to sawfly's population dynamics, which seem to experience slight changes yearly.

We are conducting a study using the survey data, to determine if landscape cover might play a role in sawfly population fluctuations. The WSS survey will be continued in 2022.

Full survey results can be found at: <https://doi.org/10.1093/jee/toab015>



Survey Methods:

A statewide survey of wheat stem sawfly infestation has been conducted since 2013 by CSU entomologists to determine the scope of infestations across the state and monitor any changes to the range and severity of the pest. Approximately 100 sites are surveyed each year after the adult sawfly flight has been completed. The number of sites collected from each county is proportional to the amount of wheat grown in the county. Collection sites are wheat fields directly adjacent to the previous year’s wheat stubble, and each site is a minimum of 10 miles apart. From each site surveyed, 100 tillers are collected and split to check for the presence of wheat stem sawfly larvae. The percentage of infested tillers is reported for each sample location, with low infestation being less than 10% of total tillers having WSS infestation, medium being between 11%-50%, and high infestation being any site with more than 50% of tillers infested.

Acknowledgments:

We would like to acknowledge the work of Dr. Frank Peairs, Darren Cockrell, and Terri Randolph for their methods development and authorship of the complete results, Jeff Rudolph and Laura Newhard for their technical support over the years, the numerous lab technicians that collected and processed these samples, the countless wheat growers of Colorado that these samples were collected from, and the Colorado Wheat Administrative Committee for their support in this project.